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Multi-scale curvature for automated identification of glaciated mountain landscapes

Günther Prasicek (1), Jan-Christoph Otto (2), David Montgomery (3), and Lothar Schrott (4)

(1) Deparment of Geoinformatics, University of Salzburg, Salzburg, Austria (guenther.prasicek@sbg.ac.at), (2) Department of Geography and Geology, University of Salzburg, Salzburg, Austria, (3) Department of Earth and Space Sciences, University of Washington, Seattle, USA, (4) Department of Geography, University of Bonn, Bonn, Germany

Automated morphometric interpretation of digital terrain data based on impartial rule sets holds substantial promise for large dataset processing and objective landscape classification. However, the geomorphological realm presents tremendous complexity in the translation of qualitative descriptions into geomorphometric semantics. Here, the simple, conventional distinction of V-shaped fluvial and U-shaped glacial valleys is analyzed quantitatively using the relation of multi-scale curvature and drainage area.

Glacial and fluvial erosion shapes mountain landscapes in a long-recognized and characteristic way. Valleys incised by fluvial processes typically have V-shaped cross-sections with uniform and moderately steep slopes, whereas glacial valleys tend to have U-shaped profiles and topographic gradients steepening with distance from valley floor. On a DEM, thalweg cells are determined by a drainage area cutoff and multiple moving window sizes are used to derive per-cell curvature over a variety of scales ranging from the vicinity of the flow path at the valley bottom to catchment sections fully including valley sides. The relation of the curvatures calculated for the user-defined minimum scale and the automatically detected maximum scale is presented as a novel morphometric variable termed Difference of Minimum Curvature (DMC). DMC thresholds determined from typical glacial and fluvial sample catchments are employed to identify quadrats of glaciated and non-glaciated mountain landscapes and the distinctions are validated by field-based geological and geomorphological maps. A first test of the novel algorithm at three study sites in the western United States and a subsequent application to Europe and western Asia demonstrate the transferability of the approach.